Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/US04/017842

International filing date: 04 June 2004 (04.06.2004)

Document type: Certified copy of priority document

Document details: Country/Office: US
Number: 60/491,100
Filing date: 30 July 2003 (30.07.2003)

Date of receipt at the International Bureau: 16 August 2004 (16.08.2004)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)

1210205

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

August 11, 2004

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE.

APPLICATION NUMBER: ***60/491,100***
FILING DATE: ***July 30, 2003***
RELATED PCT APPLICATION NUMBER: ***PCT/US04/17842***

Certified by

Jon W Dudas

Acting Under Secretary of Commerce
for Intellectual Property
and Acting Director of the U.S.
Patent and Trademark Office

Please type a plus sign (+) inside this box → [+]

PTO/SB/16 (02-01)
Approved for use through 10/31/2002. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

16424 U.S. PTO
60/491100
07/30/03

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

Express Mail Label No. EV 307982730US

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
DONALD HENRY	WILLIS	Indianapolis, Indiana

☐ *Additional inventors are being named on the _____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

DLP SPOKE LIGHT MOTION ARTIFACT COMPENSATION

CORRESPONDENCE ADDRESS

Direct all correspondence to:

☐ Customer Number [ ] → *Place Customer Number Bar Code Label here*

OR *Type Customer Number here*

☒ Firm or Individual Name	JOSEPH S. TRIPOLI, THOMSON MULTIMEDIA LICENSING INC.				
Address	PATENT OPERATIONS.				
Address	P. O. BOX 5312				
City	PRINCETON	State	NJ	ZIP	08543-5312
Country	USA	Telephone	609-734-6820	Fax	609-734-6888

ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages* [3] ☐ CD(s), Number [ ]

☒ Drawing(s) *Number of Sheets* [1] ☐ Other (specify) [ ]

☐ Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT *(check one)*

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check or money order is enclosed to cover the filing fees

☒ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: [07-0832]

☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE AMOUNT ($) [160]

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are: _____.

Respectfully submitted,

SIGNATURE ______ Date [July 30, 2003]

TYPED or PRINTED NAME ROBERT B. LEVY REGISTRATION NO. *(if appropriate)* [28,234]

TELEPHONE 609 734-6820 Docket Number: [PU030229]

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

DLP SPOKE LIGHT MOTION ARTIFACT COMPENSATION

Spokes" can be turned on to make bright pixels under certain conditions, in a DLP display. Compensating reductions in the non-spoke turn-on time is needed in order to make the right pixel brightness. In order to minimize motion artifacts, the durations of these compensating reductions are matched to the spoke light durations and placed in time as close to the spokes being compensated as possible.

When spoke light recovery is used without proper compensation, there is a severe motion artifact usually known as dynamic contouring in portions of the image which have a brightness at the spoke activation level.

In the past, as far as can be determined, the artifact was tolerated. The weakness in this is a poorer appearing display occasionally.

In a typical DLP TV set application, a single digital micromirror device (DMD) is used in combination with a color wheel to implement a color sequential display. In order to minimize the color breakup artifact of the sequential display the color sequence is shown multiple times per incoming picture. Thus the color wheel must change the DMD illumination color up to 15 times per frame (60Hz frame rate). In the first planned Thomson TV set product the illumination color is changed 12 times, making. a so-called 4X display (each color is displayed 4 times per incoming picture). When the illumination color is in transition from one color primary to the next color primary, this transition time is called a spoke. Normally, this time is not utilized by the display because one cannot easily make a saturated color with this "mixed" light. However, the TI DLP system has an option they call "spoke light recapture" (SLR) which can, under certain conditions, use some spokes' light, making a significantly brighter peak white object possible. Because the color during the spoke is constantly changing, in order to get consistent color rendition a spoke is used in its entirety or not at all. Furthermore, the typical application uses three spokes of different colors at a time, or not at all. This amounts to a large amount of added white light, typically about 9% of full non-spoke time. This light is added at a threshold brightness state, at approximately 60% of full brightness. Below this threshold, spokes are turned off.

Thus, when brightness increases from just below the threshold up to equal to the threshold, the spokes are turned on. In order to not have a large discontinuity in the brightness characteristic there needs to be a corresponding reduction in the non-spoke light so that the resultant brightness increase is only one least-significant-bit worth as wanted.

If this corresponding reduction is implemented at a very different time(s) in the picture period than that occupied by the turned-on spokes, then the conditions are produced for a severe motion contouring artifact. The invention consists of placing the correct amount of compensating reduction in the non-spoke segments immediately before and after the spoke being compensated, for every spoke that is activated.

Examples will now be given.

Figure 1 shows an embodiment of the invention showing the white-only brightness characteristic of all the colored segments <u>with the spokes disabled</u>. If the spokes would be enabled, three different colored spokes (out of 12) would be turned on at state 150 and higher. The zeros in the table below the solid line represent the spokes that would be turned on. Six zeros are used to represent three spokes because each spoke has two color primary additive components which need to be properly compensated. The numbers in the table are the sum of the pulses that are activated within each color segment, in units of least significant bits (LSB's), out of 255 maximum.

This spoke-off characteristic is employed by the SLR system when the spokes are activated, and is important for the proper spoke compensation. If this characteristic is not properly constructed, the invention is not properly implemented and the artifact will not be optimally reduced.

Figure 2 shows the white-only brightness characteristic with SLR turned on. The spoke design parameters are such that each spoke contains 8.5 LSB of each of the two constituent primary colors. Optimal compensation would require the non-spoke compensation on each side of a spoke to equal 8LSB in order to compensate

that spoke. Since some segments have an activated spoke both before and after that segment, the compensation for that segment should be 16LSB, total.

The most significant thing to note in Figure 2 is the transition from brightness state 149 to state 150. Three spokes are switched on in columns 20,21,23,24,26,and 27. In order to compensate these spokes, the non-spoke light from 16LSB lower than state 149 is utilized, namely from state 133, as shown by the number in parentheses next to the brightness state column. The blue light component of the first spoke (column 20) is optimally compensated by an 8LSB drop in the blue light of column 19. The green light component of the first spoke (column 21) plus the green light component of the second spoke (column 23) is partially compensated for by the 19LSB drop in the green light of column 22. The red light component of the second spoke (column 24) and the red light component of the third spoke (column 26) is partially compensated for by the 19LSB drop in the red light of column 25. The blue light component of the third spoke (column 27) is optimally compensated for by the 8LSB drop in the blue light of column 28. The motion compensation for these three spokes is good, but not perfect. The non-motion compensation is ideal as shown by the equivalent brightness value of column 36, which is 150 as desired.

It is important to note that the figures are given for pure white objects. In the DLP system SLR activation for a specific pixel in a specific picture period depends upon the brightness and color saturation of the pixel. As deduced from light output pulse measurements, spokes are not activated unless <u>all three primary colors are above the threshold value.</u> Thus, if a moving object has a non-saturated bright color, spokes can get activated when one or two of the primary colors are brighter than the threshold. For this reason, it is helpful if the compensation effects are optimized for brightness values somewhat above the threshold, as well as at the threshold, for the three primary color drive characteristics. Examination of Figure 1 shows that the compensation is still fairly good for brightness values up to 161. Looking at the segment brightnesses 16 brightness states below the state being examined and looking at the individual segment differences determine this. Since bright objects are often not pure white this could be important in reducing artifacts.

FIGURE 1

Diagram Column Numbers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
																SEGMENTS																		
BRIGHTNESS STATE	B			G			R			B			G			R			B			G			R			B			G			R
128	26			26			26			26			26			26			24			22			54			52			54			54
129	26			26			26			26			25			26			27			22			55			50			55			55
130	28			26			26			28			28			26			24			22			56			50			56			56
131	28			28			28			28			28			28			27			19			56			48			56			56
132	30			28			28			30			28			28			27			19			57			45			57			57
133	30			28			28			30			28			28			27			19			58			46			58			58
134	30			28			28			30			28			28			27			19			59			47			59			59
135	30			28			28			30			28			28			27			19			60			48			60			60
136	30			28			28			30			28			28			27			19			61			49			61			61
137	30			28			28			30			28			28			27			19			62			50			62			62
138	30			28			28			30			28			28			27			19			63			51			63			63
139	30			28			28			30			28			28			27			22			61			52			61			61
140	30			28			28			30			28			28			27			22			62			53			62			62
141	30			27			27			30			27			27			30			24			63			51			63			63
142	30			27			27			30			27			27			30			27			61			52			61			61
143	30			27			27			30			27			27			30			27			62			53			62			62
144	32			25			25			32			25			25			27			32			62			53			62			62
145	32			25			25			32			25			25			27			35			60			54			60			60
146	32			27			27			32			27			27			27			35			57			55			57			57
147	32			27			27			32			27			27			27			38			55			56			55			55
148	32			29			29			32			29			28			30			35			55			54			55			55
149	30			29			29			30			29			29			35			38			53			54			53			53
150	30			29			29			30			29			29			35			38			54			55			54			54
151	30			29			29			30			29			29			35			38			55			56			55			55
152	30			29			29			30			29			29			35			38			56			57			56			56
153	30			29			29			30			29			29			35			38			57			58			57			57
154	30			29			29			30			29			29			35			38			58			59			58			58
155	30			29			29			30			29			29			35			38			59			60			59			59
156	30			29			29			30			29			29			35			38			60			61			60			60
157	30			29			29			30			29			29			35			38			61			62			61			61
158	30			29			29			30			29			29			35			38			62			63			62			62
159	30			29			29			30			29			29			38			38			63			61			63			63
160	30			31			31			30			31			31			38			37			61			62			61			61
161	30			31			31			30			31			31			38			37			62			63			62			62
162	32			31			31			32			31			31			37			37			63			61			63			63

FIGURE 2

Diagram column numbers		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
																	SEGMENTS																				
BRIGHTNESS STATE		B			G			R			B			G			R			B			G			R			B			G			R		EQUIVALENT BRIGHTNESS
128		26			26			26			26			26			26			24			22			22			52			54			54		128
129		26			26			26			28			26			26			27			22			22			50			55			55		129
130		28			26			26			28			28			26			24			22			22			50			56			56		130
131		28			28			28			28			28			28			27			19			19			48			56			56		131
132		30			28			28			30			28			28			27			19			19			45			57			57		132
133		30			28			28			30			28			28			27			19			19			46			58			58		133
134		30			28			28			30			28			28			27			19			19			47			59			59		134
135		30			28			28			30			28			28			27			19			19			48			60			60		136
136		30			28			28			30			28			28			27			19			19			49			61			61		136
137		30			28			28			30			28			28			27			19			19			50			62			62		137
138		30			28			28			30			28			28			27			19			19			51			63			63		138
139		30			28			28			30			28			28			27			22			22			52			61			61		139
140		30			28			28			30			28			28			27			22			22			53			62			62		140
141		30			27			27			30			27			27			30			24			24			51			63			63		141
142		30			27			27			30			27			27			30			27			27			52			61			61		142
143		30			27			27			30			27			27			30			27			27			53			62			62		143
144		32			25			25			32			25			25			27			32			32			53			62			62		144
145		32			25			25			32			25			25			27			35			35			54			60			60		145
146		32			27			27			32			27			27			27			35			35			55			57			57		146
147		32			27			27			32			27			27			27			38			38			56			56			55		147
148		32			29			29			32			29			29			30			35			35			54			55			56		148
149		30			29			29			30			29			29			35			38			38			54			53			53		149
150	(133)	30			28			28			30			28			28			27	8.5	8.5	19	8.5	8.5	19	8.5	8.5	46			58			58		150
151	(134)	30			28			28			30			28			28			27	8.5	8.6	19	8.5	8.5	19	8.5	8.5	47			59			59		151
152	(136)	30			28			28			30			28			28			27	8.5	8.5	19	8.5	8.5	19	8.5	8.5	49			61			61		153
153	(137)	30			28			28			30			28			28			27	8.5	8.5	19	8.5	8.5	19	8.5	8.5	50			62			62		154
154	(138)	30			28			28			30			28			28			27	8.5	8.5	19	8.5	8.5	19	8.5	8.5	51			63			63		155
155	(140)	30			28			28			30			28			28			27	8.5	8.5	22	8.5	8.5	22	8.5	8.5	53			62			62		157
156	(141)	30			27			27			30			27			27			30	8.5	8.5	24	8.5	8.5	24	8.5	8.5	51			63			63		158
157	(142)	30			27			27			30			27			27			30	8.5	8.5	27	8.5	8.5	27	8.5	8.5	52			61			61		159
158	(144)	32			25			25			32			25			25			27	8.5	8.5	32	8.5	8.5	32	8.5	8.5	53			62			62		161
159	(145)	32			25			25			32			25			25			27	8.5	8.5	35	8.5	8.5	35	8.5	8.5	54			60			60		162
160	(146)	32			27			27			32			27			27			27	8.5	8.5	35	8.5	8.5	35	8.5	8.5	56			57			57		163
161	(148)	32			29			29			32			29			29			30	8.5	8.5	35	8.5	8.5	35	8.5	8.5	54			55			56		165
162	(149)	30			29			29			30			29			29			35	8.5	8.5	38	8.6	8.5	38	8.5	8.5	54			53			53		166